Calculating Soil Wetness, Evapotranspiration and Carbon Cycle processes over large grid areas using a new scaling technique

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Abstract

Soil wetness typically shows great spatial variability over the length scales of general circulation model (GCM) grid areas (~100 km), and the functions relating evapotranspiration and photosynthetic rate to local-scale (~1 m) soil wetness are highly non-linear. Soil respiration is also highly dependent on very small-scale variations in soil wetness. We therefore expect significant inaccuracies whenever we insert a single grid area-average soil wetness value into a function to calculate any of these rates for the grid area. For the particular case of evapotranspiration., this method – use of a grid-averaged soil wetness value - can also provoke severe oscillations in the evapotranspiration rate and soil wetness under some conditions. A method is presented whereby the probability distribution function(pdf) for soil wetness within a grid area is represented by binning, and numerical integration of the binned pdf is performed to provide a spatially-integrated wetness stress term for the whole grid area, which then permits calculation of grid area fluxes in a single operation. The method is very accurate when 10 or more bins are used, can deal realistically with spatially variable precipitation, conserves moisture exactly and allows for precise modification of the soil wetness pdf after every time step. The method could also be applied to other ecological problems where small-scale processes must be area-integrated, or upscaled, to estimate fluxes over large areas, for example in treatments of the terrestrial carbon budget or trace gas generation.